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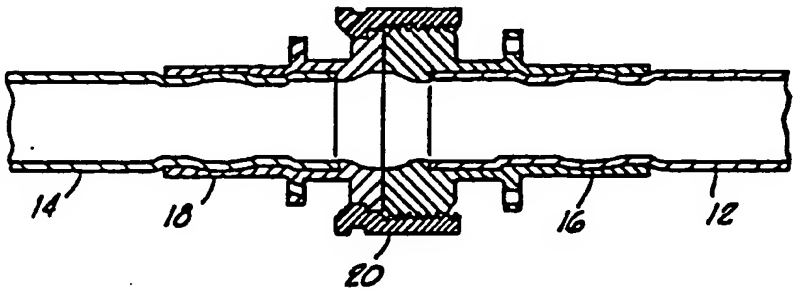

(57) Abstract

A multiple-piece swagable fitting (10) for connecting tubes (12, 14) to one another is formed from a coupling body (16), a ferrule (18) and a nut (20) for securing the coupling body (16) to the ferrule (18). The coupling body (16) has an inner portion ending in a first faying surface, an outer portion for receiving one of the tubes to be connected, an interior surface (22) defining an axial bore therethrough, and an exterior surface (24) adapted to fit within dies (36, 38) of an external swaging tool (40). The ferrule (18) has an inner portion ending in a faying surface, an outer portion for receiving a second tube to be connected, an interior surface defining an axial bore therethough, and an exterior surface adapted to fit within dies of an external swaging tool.

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MULTIPLE-PIECE EXTERNALLY SWAGABLE FITTING

BACKGROUND OF THE INVENTION

The present invention relates to fittings and in particular to a swagable fitting adapted to connect tubes to one another.

Swagable fittings are used to connect metal tubes in a variety of applications. For example, in the aerospace industry swagable fittings are used to join the rigid metal tubes that form an aircraft's or a space vehicle's electrical conduit system. Typically, the tubes are short, on the order of only about three feet, to facilitate the passing of electrical lines through each section as the conduit system is constructed. The fittings used to connect the various sections are generally internally swaged to the tubes.

It is a disadvantage of internal swaging that the swaging tool is large and complex -- too bulky to be transported inside an aerospace vehicle. Consequently, the fittings cannot be swaged inside the vehicle, but all the swaging must be performed on the outside.

It is a further disadvantage of internal swaging that the swaging tool must pass through the fitting. Therefore, curved fittings, such as fittings that are bent or that are T-shaped, cannot be used.

Externally swagable fittings also have applications in the aerospace industry, such as to convey fuel, hydraulic control fluids and the like. See for example, U.S. Patent Nos. 5,069,058 and 5,080,406. The fittings disclosed in these patents are constructed of a single piece and cannot provide the ease of use required for the construction of electrical conduit systems.

Accordingly, there has existed a definite need for fittings that can be swaged inside an aircraft or

space vehicle or in other tight or difficult to access areas. There has further existed a need for swagable, non-linear fittings and for easy to use fittings to facilitate the construction of electrical conduit systems. The present invention satisfies these and other needs and provides further related advantages.

SUMMARY OF THE INVENTION

The present invention is embodied in an externally swagable, multiple-piece fitting for connecting tubes to one another. The fitting is formed of a coupling body, a ferrule and securing means for securing the coupling body to the ferrule. The coupling body has an inner portion ending in a first faying surface, an outer portion for receiving one of the tubes to be connected, an interior surface defining an axial bore therethrough, and an exterior surface adapted to fit within dies of an external swaging tool. The ferrule has an inner portion ending in a second faying surface, an outer portion for receiving a second tube to be connected, an interior surface defining an axial bore therethrough, and an exterior surface adapted to fit within dies of an external swaging tool.

In one embodiment, the coupling body is substantially cylindrical and has external threads. The ferrule also is substantially cylindrical and has a region of increased outer diameter forming a stpped flange. In addition, the securing means comprises a nut, one end of which contains internal threads adapted to matingly engage the external threads on the coupling body, the other end of which has a region of reduced inner diameter. This region of reduced inner diameter is configured to engage the stepped flange when the nut is threaded onto the coupling body.

In one aspect of the invention, the interior surfaces of the coupling body and the ferrule define staged axial bores. The bores have outer stages located at their respective outer portions and adjacent inner stages located at their respective inner portions. The diameter of the outer stages is substantially the same as the outer diameter of the tubes, so that the outer stages are adapted to receive the tubes. The diameter of the inner stages, at the inner stage ends adjacent the outer stages is less than the inner diameter of the tubes, so that tube stops are formed. In addition, an axial undercut is formed in the tube stops, to prevent deformation of the faying surfaces when the coupling body and the ferrule are swaged. The interface between the tube ends and the tube stops, after swaging, results in a smooth transition that prevents the hang-up of electrical lines or the like passing through the tubes.

Other features and advantages of the present invention will become apparent from the following detailed description, taken in conjunction with the accompanying drawings, which illustrate, by way of example, the principles of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings illustrate the invention. In such drawings:

FIG. 1 is an exploded perspective view of a fitting embodying the novel features of the invention.

FIG. 2 is a longitudinal view, partly in cross-section, showing a coupling body, a ferrule, associated tubing and dies used in swaging.

FIG. 3 is a longitudinal view, partly in cross-section, showing the completed connection.

FIG. 4 is an enlarged and isolated cross-sectional view of a portion of the fitting shown in FIG. 2.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

As shown in the accompanying drawings, the present invention embodies an externally swagable, multiple-piece fitting indicated generally by the referenced numeral 10, for use in connecting two tubes 12 and 14 to each other. A coupling body 16, a ferrule 18, and a nut 20 for securing the coupling body to the ferrule form the fitting.

FIGS. 1 and 2 illustrate the pieces of fitting 10, along with the associated tubing 12 and 14. The coupling body 16 is a substantially cylindrical body having an inner portion for coupling to the ferrule 18 and an outer portion for swaging to the tube 12. As best seen in FIG. 2, an interior surface 22 of the coupling body 16 defines a staged axial bore for passing electrical lines (not shown) therethrough.

The stage 28 of the axial bore located at the outer portion of the coupling body 16 has a diameter substantially the same as the outer diameter of the tube 12. Thus, the outer stage 28 is adapted for receiving an end of the tube 12.

The stage 30 located at the inner portion of the coupling body 16 is tapered to facilitate the running of electrical lines through the coupling body into the tube 12. The inner stage 30 has a maximum diameter at the inner stage end adapted to receive the electrical lines. The inner stage 30 also has a reduced diameter at its opposing end adjacent to the outer stage 28. The diameter

of the end of inner stage 30 adjacent to the outer stage 28 is less than the inner diameter of the tube 14. Thus, the end of inner stage 30 adjacent to the outer stage 28 forms a tube stop 32 having a radial dimension that is at least as large as the wall thickness of the tube 12.

It is an advantage of the fittings in accordance with this invention, that when the end of the tube 12 is inserted into the coupling body 16, the tube abuts against the tube stop 34 and because of the relative radial dimensions of the tube and the tube stop, the end of the wall of the tube does not extend above the stop after swaging. This facilitates the running of wires through the fitting 10. The wires cannot get hung-up on an exposed edge of the tube and the danger of wires being stripped or otherwise damaged as they are passed across the end of the tube is virtually eliminated. It is a further advantage of this arrangement, that tubes of varying thickness can be employed, so long as the thickness of the tube's wall is less than the radial height of the tube stop 32.

The exterior surface 24 of the coupling body 16 is adapted to fit within dies 36 and 38 of a swaging tool 40. At the outer portion of the coupling body 16, the exterior surface 24 contains a swaging region 41 and, at the inner end of the swaging region 41, an annular positioning flange 42. Referring to FIG. 2, the positioning flange 42 accurately positions the coupling body 16 within the dies 36 and 38. The positioning flange 42 fits within counter bores in the dies 36 and 38 to properly align the coupling body 16 within the dies prior to swaging.

At the inner portion of the coupling body 16, the exterior surface 24 comprises a region of increased outer diameter containing external threads 44. A substantially perpendicular annular faying surface 46

forms the inner end of the coupling body.

The ferrule 18 also comprises a substantially cylindrical body having an inner portion for coupling to the coupling body 16 and an outer portion for swaging to the tube 14. An interior surface 48 of the ferrule 18 defines a staged axial bore for passing the electrical lines therethrough.

The stage 50 located at the outer portion of the ferrule 18 has a diameter substantially the same as the

outer diameter of tube 14. Thus, the outer stage 50 is adapted for receiving an end of the tube 14.

The stage 52 located at the inner portion of the ferrule 18 is tapered to facilitate the running of the electrical lines through the ferrule into the tube 14. The inner stage 52 also has a maximum diameter at the inner stage end adapted to receive the electrical lines. The inner stage 52 has a reduced diameter at its opposing end adjacent to the outer stage 50. The diameter of the end of the inner stage 52 adjacent outer stage 50 is less than the internal diameter of the tube 14. Thus, the end of the inner stage 52 adjacent to the outer stage 50 forms a tube stop 56 having a radial dimension that is at least as large as the wall thickness of the tube 14.

The exterior surface 58 of the ferrule 18 is adapted to fit within dies (not shown) of a swaging tool. At the outer portion of the ferrule 18, the exterior surface 58 contains a swaging region 60 and, at the inner end of the swaging region, a positioning flange 62.

At the inner portion of the ferrule 18, the exterior surface 58 comprises a region of increased outer diameter forming a stepped flange 64. A substantially perpendicular annular faying surface 66 forms the inner end of the ferrule 18.

One end of the nut 20 contains internal threads 68 adapted to matingly engage the external threads 44 on the coupling body 16. The other end of the nut 18 contains a shoulder 63 formed by a region having a reduced inner diameter. As best seen in FIG. 3, the shoulder is configured to mate with a corresponding shoulder 65 on the surfaces of the stepped flange 64.

As best seen in FIG. 4, there is an annular groove or undercut 70 in the tube stop 56 formed by a slight extension of the outer stage 50 beneath the inner stage 52. The tube stop 32 in the coupling body 16

contains a similar annular groove or undercut 72.

The swaging operation is shown in FIGS. 3 and 4. Before swaging, the interior surfaces in the swaging area of the outer stages 28 and 50 are smooth. The exterior surfaces in the swaging regions 41 and 60 each contain an annular groove 74 of reduced outer diameter flanked by a pair of annular ridges 76.

The right portion of FIG 2. illustrates one embodiment of the construction of the dies 36 and 38 used in the swaging tool 40 that is of the type that may be used to externally swage the coupling body 16 and the ferrule 18 to the tubes 12 and 14, respectively. The swaging tool 40 in the preferred embodiment includes an upper die 38 received within a stationary head 78 of the tool, and a lower die 36 received within a lower die holder 80 adapted to be moved toward the upper die by a piston or other suitable means (not shown). Each of the dies 36 and 38 of the swaging tool 40 has a swaging surface 82 adapted to swage the outer portion of the coupling body 16.

During the swaging operation, the annular ridges 76 are compressed inwardly by the dies 36 and 38 of the swaging tool 40. The compression results in an irregular configuration along the interior surface of the stages 28 and 50 that grip the tubes 12 and 14 tightly, forming a metal to metal seal. It is an advantage of the fittings in accordance with this invention that the axial undercuts 70 and 72 prevent deformation of the faying surfaces 46 and 66, while the coupling body 16 and the ferrule 18 are swaged.

FIG. 3 illustrates the completed connection. The tube 12 is connected to the tube 14 when the coupling body 16 is secured to the ferrule 18 by the nut 20. The nut 20 passes over the tube 14, over the outer portion of

the ferrule 18, and then over the positioning flange 62. The internal threads 68 of the nut 20 engage the external threads 44 on the coupling body 16. A scored portion (not shown) on the nut's outside surface facilitates the hand-tightening of the nut 20 onto the coupling body 16. The surface of the shoulder 63 engages the stepped flange 64, thereby securing the two faying surfaces 46 and 66 against one another. The holes 84 in the ferrule's positioning flange 62 and the holes 86 (one shown) in the nut 20 enable the locking of the completed connection with a lockwire (not shown). In some embodiments the faying surfaces are alodizing using conventional techniques, to help conduct electricity once the connection has been completed.

In the preferred embodiment the coupling body 16 and ferrule 18 are constructed from aluminum or stainless steel materials, such as aluminum 6061-0 or stainless steel 21-6-9. The nut 20 also is preferably constructed from aluminum or stainless steel materials, such as aluminum 6061-T6 or stainless steel 21-6-9, or stainless steel 304. All of these components can be manufactured from titanium or other suitable metals, as desired.

In addition to the advantages of the invention described above, a further advantage resides in the fact that the fitting 10 can be externally swaged to the tubes 12 and 14 on board the aircraft or the like using existing external swaging tools. These swaging tools can be portable and relatively lightweight, such as the Model DLT swaging tool available from Deutsch Metal Components of Gardena, California. This type of external swaging tool also is disclosed and claimed in U.S. Patent No. 5,069,058. As a result, all of the problems and drawbacks associated with internal swaging operations are eliminated. There is no need to have all of the swaging

performed off-site, and greater versatility is enabled since elbow, T-shaped and other curved fitting configurations can be used, inasmuch as they are adapted for external swaging. Moreover, after the tubes 12 and 14 have been swaged to the coupling body 16 and the ferrule 18, a relatively smooth transition, instead of a sharp edge, is provided along the interface between the tube stops 32 and 56 and the tube ends. As noted above, this facilities running of electrical lines through the fitting 10.

While a particular form of the invention has been illustrated and described, it will be apparent that various modifications can be made without departing from the spirit and scope of the invention, Accordingly, it is not intended that the invention be limited, except as by the appended claims.

I claim:

1. A multiple-piece swagable fitting for connecting first and second tubes comprising:

a coupling body, a ferrule and means for securing the coupling body to the ferrule;

the coupling body having an inner portion for coupling with the ferrule, an outer portion for receiving the first tube, an interior surface defining an axial bore therethrough, and an exterior surface having a region for swaging by an external swaging tool; and

the ferrule having an inner portion for coupling with the coupling body, an outer portion for receiving the second tube, an interior surface defining an axial bore therethrough, and an exterior surface having a region for swaging by an external swaging tool.

2. The fitting of claim 1 wherein the coupling body is substantially cylindrical and the inner portion of the coupling body has external threads; the ferrule is substantially cylindrical and the inner portion of the ferrule has a region of increased outer diameter forming a stepped flange; and the securing means comprises a nut, one end of the nut containing internal threads adapted to matingly engage the external threads on the coupling body, the other end of the nut having a region of reduced inner diameter, the region of reduced diameter having a shoulder configured to engage the stepped flange on the ferrule when the nut is threaded onto the coupling body.

3. The fitting of claim 4 wherein the interior surface of the coupling body defines a staged axial bore comprising an outer stage located at the outer portion of the coupling body adjacent to an inner stage

located at the inner portion of the coupling body, the diameter of the outer stage being substantially the same as the outer diameter of the first tube, the diameter of the inner stage at an inner stage end adjacent the outer stage being less than the inner diameter of the first tube, to form a first tube stop.

4. The fitting of claim 1 wherein the interior surface of the ferrule defines a staged axial bore comprising an outer stage located at the outer portion of the ferrule adjacent to an inner stage located at the inner portion of the ferrule, the diameter of the outer stage being substantially the same as the outer diameter of the second tube, the diameter of the inner stage at an inner stage end adjacent the outer stage being less than the inner diameter of the second tube, to form a second tube stop.

5. The fitting of claim 3 further comprising an annular undercut in the first tube stop.

6. The fitting of claim 4 further comprising an annular undercut in the second tube stop.

7. The fitting of claim 3 wherein the coupling body's inner stage tapers from the inner stage end adjacent the outer stage to the inner stage end distant the outer stage.

8. The fitting of claim 4 wherein the ferrule's inner stage tapers from the inner stage end adjacent the outer stage to the inner stage end distant the outer stage.

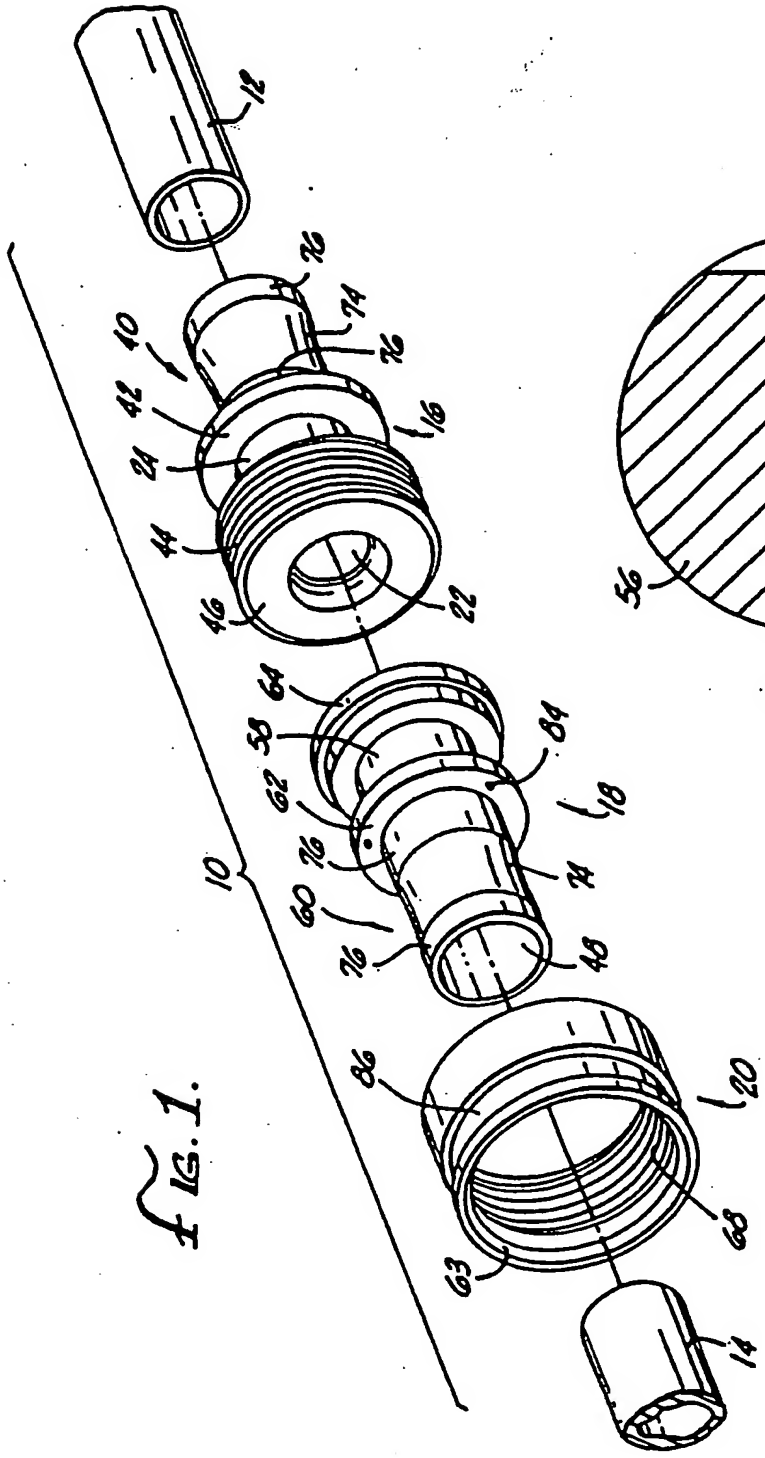
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FIG. 1.

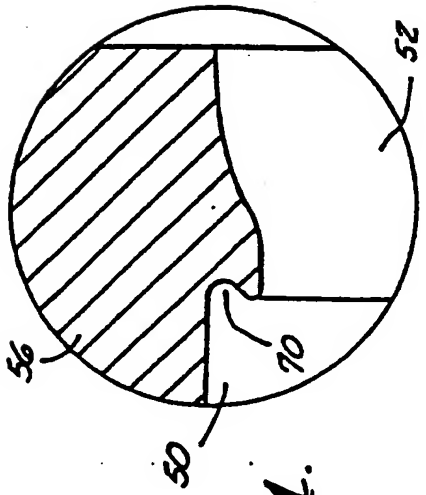
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FIG. 4.

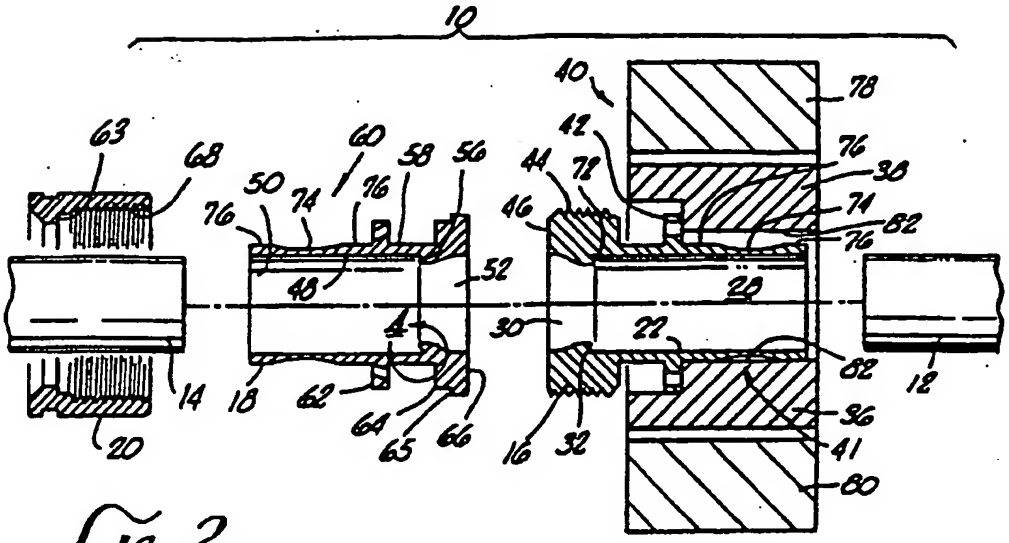
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FIG. 2.

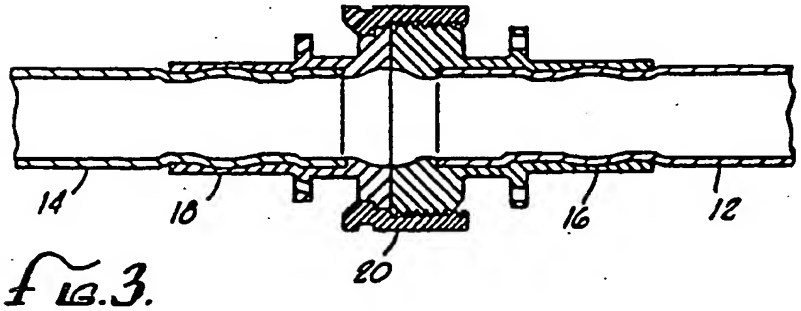
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FIG. 3.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US93/05217

A. CLASSIFICATION OF SUBJECT MATTER
IPC(5) :F16L 13/14
US CL :285/382.2,286,417,381.1,382.4,382.5
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
U.S. : 285/382.2,286,417,381.1,382.4,382.5

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US,A, 1,993,372 (JONES) 05 MARCH 1935 (ENTIRE DOCUMENT)	1-8
Y	US,A, 3,149,860 (HALLESY) 22 SEPTEMBER 1964 (ENTIRE DOCUMENT)	1-2
Y	US,A, 3,484,123 (VAN DER VELDEN) 16 DECEMBER 1969 (ENTIRE DOCUMENT)	3-6
Y	US,A,3,482,860 (DAWBARN ET AL) 09 DECEMBER 1969, (ENTIRE DOCUMENT)	7-8

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Date of the actual completion of the international search	Date of mailing of the international search report
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